PB-239 552

DELAVAN LAKE, WALWORTH COUNTY, WISCONSIN

Pacific Northwest Environmental
Research Laboratory

Prepared for:

National Environmental Research Center
Wisconsin National Guard
Wisconsin Department of Natural Resources

October 1974

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT
ON
DELAVAN LAKE
WALWORTH COUNTY
WISCONSIN

EPA REGION V

WORKING PAPER No. 3C

WITH THE COOPERATION OF THE

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

AND THE

WISCONSIN NATIONAL GUARD

OCTOBER, 1974

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Wisconsin Department of Natural Resources for professional involvement and to the Wisconsin National Guard for conduct of the tributary sampling phase of the Survey.

Francis H. Schraufnagel, Acting Assistant Director, and Joseph R. Ball of the Bureau of Water Quality, and Donald R. Winter, Lake Rehabilitation Program, provided invaluable lake documentation and counsel during the Survey. Central Office and District Office personnel of the Department of Natural Resources reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper series.

Major General James J. Lison, Jr., the Adjutant General of Wisconsin, and Project Officer CW-4 Donald D. Erickson, who directed the volunteer efforts of the Wisconsin National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

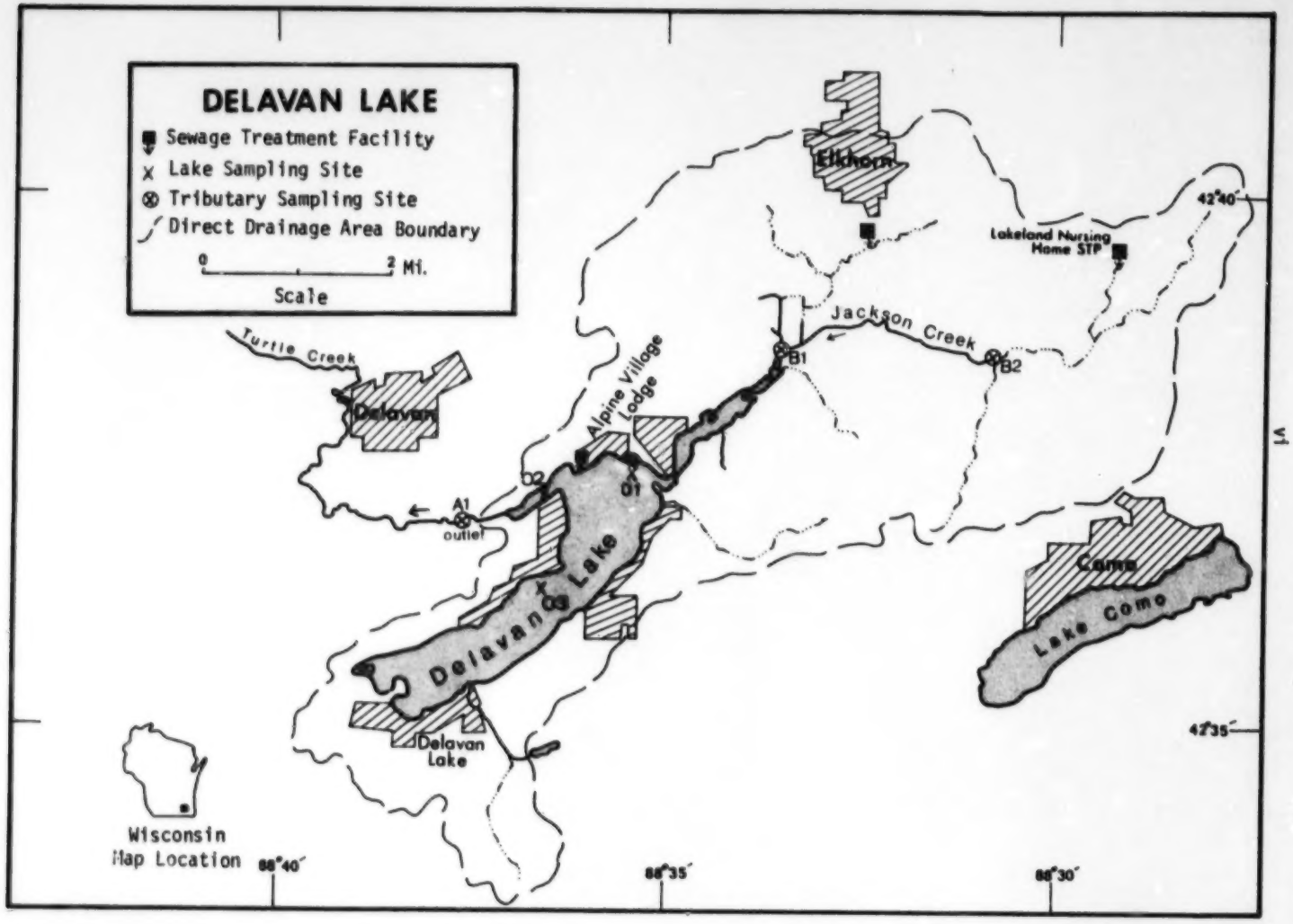
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF WISCONSIN

LAKE NAME	COUNTY
Altoona	Eau Claire
Beaver Dam	Barron
Beaver Dam	Dodge
Big Eau Pleine	Marathon
Browns	Racine
Butte des Morts	Winnebago
Butternut	Price, Ashland
Castle Rock Flowage	Juneau
Como	Walworth
Crystal	Vilas
Delavan	Walworth
Eau Claire	Eau Claire
Elk	Price
Geneva	Walworth
Grand	Green Lake
Green	Green Lake
Kegonsa	Dane
Koshkonong	Jefferson, Rock, Dane
Lac La Belle	Waukesha
Long	Price
Middle	Walworth
Nagawicka	Waukesha
Oconomowoc	Waukesha
Okauchee	Waukesha
Petenwell Flowage	Juneau
Pewaukee	Waukesha
Pigeon	Waupaca
Pine	Waukesha
Poygan	Winnebago, Waushara
Rock	Jefferson
Rome Pond	Jefferson, Waukesha
Round	Waupaca
Shawano	Shawano

LAKE NAME	COUNTY
Sinnissippi	Dodge
Swan	Columbia
Tainter	Dunn
Tichigan	Racine
Townline	Oneida
Trout	Vilas
Wapogassett	Polk
Wausau	Marathon
Willow	Oneida
Winnebago	Winnebago, Fond Du Lac, Calumet
Wisconsin	Columbia
Wissota	Chippewa
Yellow	Burnett


DELAVAN LAKE
Sewage Treatment Facility
Lake Sampling Site
Tributary Sampling Site
Direct Drainage Area Boundary
0
2 Mi.
Scale
Elkhorn
Lakeland Nursing Home STP
42°40'
Jackson Creek
B1
B2
Turtle Creek
Delavan
Alpine Village Lodge
D2
D1
A1
outlet
Delavan Lake
Como
Lake Como
42°35'
Delavan Lake
Wisconsin
Map Location
88°40'
88°35'
88°30'
VI

DELAVAN LAKE

STORET NO. 5513

I. CONCLUSIONS

A. Trophic Condition:

Survey data and the records of others show that Delavan Lake is highly eutrophic.

B. Rate-Limiting Nutrient:

Algal assay results show Delavan Lake was nitrogen limited at the time the sample was collected. The lake data indicate nitrogen limitation at the other sampling times as well.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Delavan Lake received a total phosphorus load at a rate over three times the rate proposed by Vollenweider (in press) as "dangerous"; i.e., a eutrophic rate (see page 15). Of that load, three point sources are estimated to have contributed just over 75%.

In the following table the total phosphorus loading rates that can be achieved by specified levels of phosphorus removal at all three point sources are shown and compared to Vollenweider's suggested rates.

% P Removal	Total P Loading lbs/acre/yr	Total P Loading $g/m^2/yr$
Existing	10.0	1.12
50	6.2	0.69
70	4.7	0.52
80	3.9	0.44
90	3.2	0.36
100	2.4	0.27
Vollenweider:		
"Dangerous"		0.32
"Permissible"		0.16

Of the above removal options, only 100% P removal would result in a loading rate less than the "dangerous" rate. It appears that level of removal could feasibly be achieved only by diversion.

At this time, there are five wastewater treatment facilities in the Delavan Lake vicinity within a distance of about 10 miles (two plants do not affect the lake). If the existing Delavan Lake Sanitary District could be enlarged to accomodate all of these discharges, as well as lakeside residences, with a single regional treatment facility discharging to Turtle Creek downstream from the lake, 100% removal would be effectively, and perhaps more economically, achieved.

It is concluded that 100% removal or complete diversion would result in a marked improvement in the trophic condition of Delavan Lake. The improvement could be enhanced--and the period of recovery

shortened--if the outlet dam could be operated to permit maximum flushing for two or three years.

The Wisconsin Department of Natural Resources has directed the City of Elkhorn to institute phosphorus removal (Schraufnagel, 1974). It is estimated that 80% removal at Elkhorn would reduce the loading rate to the lake to 5.4 lbs/acre/yr or 0.61 $g/m^2/yr$. It is believed this reduction in loading rate would result in a marked reduction in the incidence and severity of nuisance algal blooms in Delavan Lake.

2. Non-point sources--The nutrient export loads for Jackson Creek (see page 15) were derived by subtracting estimated point-source loads from the loads measured at station B-1. The annual phosphorus export appears to be somewhat high but may be due to underestimation of the point-source loads.

II. INTRODUCTION

Delavan Lake is a natural lake in the lower Rock River drainage in south-central Wisconsin. The level of the lake is controlled by a 14-foot head dam on the outlet

The lake is essentially a resort and residence lake. An estimated 6,500 permanent residents live in cottages and homes in the immediate drainage area (less than one mile in almost 18 miles of frontage is in public ownership).

Delavan Lake is managed for largemouth bass, panfish, and walleyes; swimming (one public beach) and boating (one public ramp and seven boat rental liveries) are other recreational activities. The proximity of the lake to metropolitan areas insures a heavy recreational use.

III. LAKE AND DRAINAGE BASIN CHARACTERISTICS

A. Lake Morphometry*:

1. Surface area: 1,774 acres.
2. Mean depth: 25 feet.
3. Maximum depth: 56 feet.
4. Volume: 44,435 acre/feet.
5. Mean hydraulic retention time: 2.8 years.

B. Tributary and Outlet:
(See Appendix A for flow data)

1. Tributaries -

Name	Drainage area†	Mean flow†
Jackson Creek	15.3 mi^2	7.8 cfs
Minor tributaries & immediate drainage -	22.5 mi^2	14.0 cfs
Totals	37.8 mi^2	21.8 cfs

2. Outlet -

Turtle Creek	40.6 mi^{2}††	21.8 cfs

C. Precipitation†††:

1. Year of sampling: 38.7 inches.
2. Mean annual: 30.7 inches.

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* Ball, 1973.
† Drainage areas are accurate within ±0.5%; mean daily flows are accurate within ±40%; mean monthly flows are accurate within ±35%; and normalized mean monthly flows are accurate within ±35%.
†† Includes area of lake.
††† See Working Paper No. 1, "Survey Methods".

IV. LAKE WATER QUALITY SUMMARY

Delavan Lake was sampled three times during the open-water season of 1972 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and from one or more depths at each station (see map, page vi). During each visit, a single depth-integrated (15 feet or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the last visit, a single five-gallon depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 8 feet at station 1, 4 feet at station 2, and 50 feet at station 3.

The results obtained are presented in full in Appendix B, and the data for the fall sampling period, when the lake was essentially well-mixed, are summarized below. Note, however, the Secchi disc summary is based on all values.

For differences in the various parameters at the other sampling times, refer to Appendix B.

A. Physical and chemical characteristics:

Parameter	Minimum	Mean	Median	Maximum
		FALL VALUES (11/10/72)		
Temperature (Cent.)	7.0	8.4	8.6	8.7
Dissolved oxygen (mg/l)	8.5	9.1	9.0	10.1
Conductivity (μmhos)	470	482	470	510
pH (units)	7.9	8.0	8.0	8.1
Alkalinity (mg/l)	162	167	167	174
Total P (mg/l)	0.135	0.140	0.141	0.143
Dissolved P (mg/l)	0.126	0.129	0.130	0.134
NO_2 + NO_3 (mg/l)	0.160	0.191	0.170	0.260
Ammonia (mg/l)	0.760	0.816	0.830	0.870
		ALL VALUES		
Secchi disc (inches)	13	50	36	126

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Number per ml
06/23/72	1. Oscillatoria	11,818
	2. Anabaena	2,000
	3. Dinobryon	1,364
	4. Synedra	1,000
	5. Polycystis	727
	6. Scenedesmus	727
	Other genera	2,000
	Total	19,636
08/17/72	1. Oscillatoria	5,973
	2. Anabaena	2,624
	3. Cyclotella	950
	4. Chroococcus	543
	5. Melosira	272
	Other genera	1,041
	Total	11,403
11/10/72	1. Fragilaria	2,035
	2. Flagellates	1,306
	3. Dinobryon	829
	4. Melosira	402
	5. Navicula	251
	Other genera	1,232
	Total	6,055

2. Chlorophyll a -
(Because of instrumentation problems during the 1972 sampling, the following values may be in error by plus or minus 20 percent.)

Sampling Date	Station Number	Chlorophyll a (µg/l)
06/23/72	01	67.8
	02	169.8
	03	50.8
08/17/72	01	18.2
	02	62.4
	03	10.2
11/10/72	01	4.4
	02	6.4
	03	5.4

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.110	0.790	19.9
0.006 P	0.116	0.790	20.3
0.012 P	0.122	0.790	20.2
0.024 P	0.134	0.790	19.9
0.060 P	0.170	0.790	20.6
0.060 P + 10.0 N	0.170	10.790	87.4
10.0 N	0.110	10.790	40.2

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Delavan Lake was quite high at the time the sample was collected. The assay results also show that the lake was

nitrogen limited. Note the lack of significant response to increased levels of orthophosphate, until nitrogen was also added, and the significant increase in yield when only nitrogen was added.

The lake data indicate nitrogen limitation at the other sampling times as well (N/P ratios were 5/1 or less, and nitrogen limitation would be expected).

D. Trophic Condition:

Survey data and the records of others (Leuschow, et al., 1970) show that Delavan Lake is quite eutrophic. Survey limnologists observed heavy algal blooms in June and August but noted that only small, relatively isolated patches of rooted aquatic vegetation were seen.

Wisconsin records show that Delavan Lake has been treated with copper sulfate for algae control every year of the period of record (1950-1970); over 85,000 pounds of the chemical were applied in the 21-year period (Leuschow, 1972).

Of the 46 Wisconsin lakes studied, 39 had less mean total and dissolved phosphorus, 37 had less mean inorganic nitrogen, 37 had less mean chlorophyll a, and only 3 had greater algal assay control yields.

Essentially no oxygen was found in the hypolimnion in June and August.

V. NUTRIENT LOADINGS
(See Appendix C for data)

For the determination of nutrient loadings, the Wisconsin National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the high runoff months of April and May when two samples were collected. Sampling was begun in September, 1972, and was completed in August, 1973.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Wisconsin District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for the sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated by using the nutrient loads, in $lbs/m^2/year$, in Jackson Creek at station B-1, minus the estimated point-source loads, and multiplying by the ZZ area in mi^2.

The operator of the Alpine Village Lodge wastewater treatment plant provided monthly effluent samples and corresponding flow data. The City of Elkhorn and the Lakeland Nursing Home declined participation in the Survey, and nutrient loads from those sources were estimated*.

In the following loading tables, the loads given for Jackson Creek are those measured at station B-1 minus the estimated point-source loads.

* See Working Paper No. 1.

A. Waste Sources:

1. Known municipal -

Name	Pop.* Served	Treatment	Mean Flow (mgd)	Receiving Water
Elkhorn	4,000	Trickling filter	0.400*	Jackson Creek
Alpine Village Lodge	600	Act. sludge	0.055	Delavan Lake
Lakeland Nursing Home	950	Act. sludge	0.095*	Jackson Creek
Walworth Co. Corr. Ctr.	900	Act. sludge	0.090*	No discharge

2. Industrial - None known

* Estimated; see Working Paper No. 1.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	lbs P/ yr	% of total
a. Tributaries (non-point load) -		
Jackson Creek	1,470	8.3
b. Minor tributaries & immediate drainage (non-point load) -	2,160	12.2
c. Known municipal STP's -		
Elkhorn	10,000	56.6
Alpine Village Lodge	990	5.6
Lakeland Nursing Home	2,380	13.5
d. Septic tanks* -	380	2.2
e. Industrial - None known	-	-
f. Direct precipitation** -	280	1.6
Total	17,660	100.0

2. Outputs -

Lake outlet - Turtle Creek 7,910

3. Net annual P accumulation - 9,750 pounds

* Estimated 1,500 permanent lakeshore residents; see Working Paper No. 1.
** Estimated; see Working Paper No. 1.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	lbs N/ yr	% of total
a. Tributaries (non-point load) -		
Jackson Creek	24,810	18.7
b. Minor tributaries & immediate drainage (non-point load) -	36,500	27.5
c. Known municipal STP's -		
Elkhorn	30,000	21.6
Alpine Village Lodge	3,030	2.3
Lakeland Nursing Home	7,120	5.4
d. Septic tanks* -	14,100	10.6
e. Industrial - None known	-	-
f. Direct precipitation** -	17,090	12.9
Total	132,650	100.0

2. Outputs -

Lake outlet - Turtle Creek 124,790

3. Net annual N accumulation - 7,760 pounds

* Estimated 1,500 permanent lakeshore residents; see Working Paper No. 1.
** Estimated; see Working Paper No. 1.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	lbs P/mi^2/yr	lbs N/mi^2/yr
Jackson Creek	96	1,622

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (in press). Essentially, his "dangerous" rate is the rate at which the receiving waters would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

	Total Phosphorus		Total Nitrogen	
Units	Total	Accumulated	Total	Accumulated
lbs/acre/yr	10.0	5.5	74.8	4.4
grams/m^2/yr	1.12	0.64	8.4	0.5

Vollenweider loading rates for phosphorus (g/m^2/yr) based on mean depth and mean hydraulic retention time of Delavan Lake:

"Dangerous" (eutrophic rate)	0.32
"Permissible" (oligotrophic rate)	0.16

VI. LITERATURE REVIEWED

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TRIBUTARY FLOW INFORMATION FOR WISCONSIN 9/30/74

LAKE CODE 5513 DELEVAN LAKE

TOTAL DRAINAGE AREA OF LAKE 40.60

TRIBUTARY	SUB-DRAINAGE AREA	NORMALIZED FLOWS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
551341	40.60	15.60	17.50	54.50	41.00	22.40	30.20	13.60	9.70	11.70	12.60	20.40	11.70	21.80
551381	15.30	4.90	7.00	22.00	15.80	7.60	9.70	4.50	3.50	4.20	4.30	6.90	3.50	7.75
551322	25.30	10.00	11.00	35.00	27.00	14.00	20.00	8.90	6.40	7.70	8.30	13.00	7.40	14.05

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 40.60
SUM OF SUB-DRAINAGE AREAS = 40.60

TOTAL FLOW IN = 261.80
TOTAL FLOW OUT = 261.70

MEAN MONTHLY FLOWS AND DAILY FLOWS

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
551341	9	72	28.00	22	47.00				
	10	72	15.00	20	11.00				
	11	72	13.00	29	2.60				
	12	72	9.20	27	8.00				
	1	73	29.00	29	25.00				
	2	73	38.00	24	23.00				
	3	73	50.00	20	41.00				
	4	73	200.00	14	140.00	30	280.00		
	5	73	92.00	17	54.00	26	59.00		
	6	73	33.00	22	32.00				
	7	73	19.00	22	18.00				
	8	73	10.00	24	9.00				
551381	9	72	4.70	22	7.00				
	10	72	2.60	20	1.00				
	11	72	2.30	29	4.50				
	12	72	1.60	27	1.40				
	1	73	8.00	29	7.40				
	2	73	8.00	24	7.40				
	3	73	16.00	20	12.00				
	4	73	93.00	14	64.00	30	120.00		
	5	73	34.00	17	20.00	26	22.00		
	6	73	11.00	22	10.00				
	7	73	6.30	22	5.90				
	8	73	2.90	24	2.60				
551322	9	72	12.00	22	20.00				
	10	72	6.40	20	4.50				
	11	72	5.80	29	3.50				
	12	72	4.00	27	3.40				
	1	73	15.00	29	14.00				
	2	73	23.00	24	14.00				
	3	73	29.00	20	23.00				
	4	73	140.00	14	98.00	30	190.00		
	5	73	58.00	17	34.00	26	37.00		
	6	73	19.00	22	18.00				
	7	73	11.00	22	11.00				
	8	73	5.60	24	5.00				

APPENDIX B

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 74/09/30

551301
42 37 18.0 088 35 24.0
LAKE DELAVAN
55 WISCONSIN

11EPALES
3

2111202
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/23	11 05	0000	18.4	10.6	72	460	8.80	129	0.050	0.070	0.139	0.109
72/08/17	15 45	0000			24	400	8.90	142	0.060	0.090	0.103	0.033
	15 45	0004	23.9	11.1		395	8.90	138	0.090	0.090	0.092	0.032
	15 45	0008	23.8	11.2		485	8.90	141	0.090	0.090	0.111	0.037
72/11/10	11 25	0000			60	495	8.10	168	0.210	0.800	0.138	0.127
	11 25	0004	8.2	9.3		495	8.10	169	0.210	0.780	0.143	0.130

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/23	11 05	0000	67.8J
72/08/17	15 45	0000	18.2J
72/11/10	11 25	0000	4.4J

J* VALUE KNOWN TO BE IN ERROR

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STORET RETRIEVAL DATE 74/09/30

551302
42 37 00.0 088 36 48.0
DELAVAN LAKE
55 WISCONSIN

11EPALES 2111202
3 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/23	11 30	0000	18.4	10.2	36	440	8.90	175	0.060	0.030	0.161	0.110
72/08/17	16 10	0000			13	390	9.00	126	0.100	0.090	0.209	0.048
	16 10	0004	28.0	13.4		385	9.10	126	0.090	0.090	0.241	0.061
72/11/10	11 35	0000			60	510	8.00	174	0.250	0.760	0.141	0.126
	11 35	0004	7.0	10.1		500	8.00	171	0.260	0.770	0.141	0.130

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/23	11 30	0000	169.8J
72/08/17	16 10	0000	62.4J
72/11/10	11 35	0000	6.4J

8

J= VALUE KNOWN TO BE IN ERROR

STORET RETRIEVAL DATE 74/09/30

551303
42 36 06.0 088 36 36.0
DELAVAN LAKE
55 WISCONSIN

11EPALES 2111202
3 0045 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00630 NO2&NO3 N-TOTAL MG/L	00610 NH3-N TOTAL MG/L	00665 PHOS-TOT MG/L P	00666 PHOS-DIS MG/L P
72/06/23	11	40 0000	19.6	10.8	24	450	8.90	188	0.100	0.030	0.129	0.110
	11	40 0025	18.6	10.3		450	8.80	181	0.170	0.080	0.157	0.043
	11	40 0040	9.4	0.4		480	7.60	179	0.090	0.220	0.352	0.346
72/08/17	17	15 0000			31	395	8.90	140	0.060	0.050	0.097	0.038
	17	15 0004	23.6	11.4		390	8.90	140	0.070	0.060	0.097	0.040
	17	15 0015	22.8	9.4		400	8.80	145	0.060	0.060	0.091	0.037
	17	15 0020	22.6	8.8		400	8.80	137	0.060	0.070	0.089	0.036
	17	15 0030	19.8	1.4		500	7.40	149	0.180	0.085	0.145	0.182
	17	15 0040	12.0	0.0		480	7.30	202	0.090	2.520	0.536	0.476
	17	15 0050	10.0	0.0		500	7.20	214	0.080	3.320	0.660	0.566
72/11/10	11	00 0000			126	480	7.90	165	0.170	0.870	0.135	0.126
	11	00 0004	8.7	8.7		470	8.00	162	0.160	0.840	0.138	0.128
	11	00 0015	8.6	9.1		470	8.00	164	0.170	0.840	0.142	0.134
	11	00 0025	8.6	9.2		470	8.00	165	0.160	0.830	0.141	0.130
	11	00 0035	8.6	9.0		470	8.00	167	0.170	0.830	0.142	0.132
	11	00 0045	8.6	8.8		470	8.00	164	0.170	0.840	0.143	0.132
	11	00 0050	8.6	8.5		470	8.00	167	0.170	0.820	0.135	0.128

DATE FROM TO	TIME OF DAY	DEPTH FEET	32217 CHLRPHYL A UG/L
72/06/23	11	40 0000	50.8J
72/08/17	17	15 0000	10.2J
72/11/10	11	00 0000	5.4J

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J= VALUE KNOWN TO BE IN ERROR

APPENDIX C

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 74/10/02

5513A1 LS5513A1
42 37 00.0 088 37 30.0
UNNAMED CREEK
55099 15 DELAVAN
O/DELAVAN LAKE
CO HWY XING 1 MI SE OF DELAVAN
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/09/22	15 30		0.054	2.050	0.066	0.050	0.132
72/10/20	17 20		0.143	1.650	0.215	0.063	0.150
72/11/29	15 45		1.020	1.680	0.480	0.138	0.195
73/01/29	15 30		0.095	1.470	0.010	0.025	0.175
73/02/24	12 10		0.470	1.800	0.510	0.132	0.200
73/03/20	11 55		1.940	1.760	0.230	0.124	0.255
73/04/14	17 00		2.200	2.200	0.088	0.176	0.210
73/04/30	15 10		0.620	1.300	0.270	0.105	0.172
73/05/17			2.100	1.100	0.012	0.015	0.100
73/05/26	12 00		0.600	1.680	0.140	0.090	0.135
73/06/22	14 45		0.110	1.800	0.031		0.180
73/07/22	12 40		2.900	1.900	0.235	0.069	0.220
73/08/24	08 20		2.500	1.470	0.075	0.044	0.145

STORET RETRIEVAL DATE 74/10/02

551381 LS551381
42 38 30.0 088 33 30.0
JACKSON CREEK
55 15 DELAVAN
I/DELAVAN LAKE
CO RD BRDG 1.5 MI S OF ELKHORN BELO STP
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/09/22	15 10		0.817	1.750	0.089	0.220	0.410
72/10/20	16 30		0.745	1.800	0.590	0.275	0.290
72/11/29	16 10		1.160	1.320	0.670	0.710	0.790
72/12/27	08 45		1.780	5.100	2.600	0.320	1.470
73/01/29	15 30		2.900	2.800	0.665	0.490	0.620
73/02/24	12 05		1.840	1.700	0.670	0.780	0.930
73/03/20	11 50		3.500	1.600	0.198	0.340	0.425
73/04/14	17 30		0.520	1.680	0.180	0.105	0.430
73/04/30	15 00		2.200	1.380	0.105	0.230	0.360
73/05/17	17 15		2.300	1.500	0.440	0.450	0.560
73/05/26	13 15		2.900	2.100	0.190	0.240	0.315
73/06/22	14 45		0.132	2.300	0.130		1.050
73/07/22	12 10		1.340	3.700	1.580	1.900	2.100
73/08/24	09 00		2.100	3.400	1.400	2.600	2.800

STORET RETRIEVAL DATE 74/10/02

551342 LS551382
42 38 30.0 088 31 30.0
JACKSON CREEK
55 15 DELAVAN
T/DELAVAN LAKE
CO RD XING SSE OF ELKHORN ABOV STP
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
72/09/22	14 20		0.910	1.600	0.132	0.024	0.260
72/10/20	17 00		2.000	1.200	0.066	0.039	0.084
72/11/29	15 15		1.160	0.100K	0.015	0.038	0.058
72/12/27	08 30		2.500	0.990	0.189	0.042	0.105
73/01/29	15 35		2.900	2.100	0.170	0.310	0.400
73/02/24	12 00		2.100	0.660	0.200	0.048	0.090
73/03/20	11 35		3.800	1.400	0.037	0.117	0.483
73/04/14	16 30		2.400	2.400	0.126	0.152	0.402
73/04/30	15 45		2.100	1.050	0.054	0.160	0.220
73/05/17	16 40		2.500	0.810	0.023	0.040	0.075
73/05/26	12 20		2.800	0.930	0.029	0.110	0.145
73/06/22	14 15		0.022	1.050	0.013	0.005K	0.185
73/07/22	12 20		0.147	0.580	0.084	0.035	0.070
73/08/24	09 20		0.069	2.000	0.176	0.069	0.080

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K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 74/09/30

561353 45561353 P000600
42 37 30.0 088 36 00.0
ALPINE VLG
55099 15 DELAVAN
D/LAKE DELAVAN
LAKE DELAVAN
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/01/13	11 30		33.900	2.900	0.050	7.850	9.300	0.100	0.060
73/03/10	11 30		20.400	1.900	0.072	8.550	8.550	0.050	0.040
73/04/14	13 00		5.100	2.600	0.093	2.700	3.450	0.100	0.150
73/05/19	14 30		9.100	7.700	0.100	3.700	2.900	0.050	0.050
73/06/09	15 30		13.200	0.810	0.135	2.400	2.500	0.050	0.040
73/08/18	14 00		7.400	0.800	0.084	4.150	4.400	0.100	0.080
73/09/23	14 00		15.400	1.400	0.440	5.200	7.600	0.050	0.040
73/10/13	13 00		20.800	0.950	0.043	7.700	8.000	0.040	0.030
73/11/12	14 00		1.150	10.500	1.050	3.500	6.000	0.030	0.040
74/01/07	14 00		0.040	15.000	6.720	5.040	5.040	0.080	0.060
74/02/16	14 00		33.000	1.000K	6.000	4.400	9.200	0.030	0.020

K VALUE KNOWN TO BE LESS THAN INDICATED